

# Pressure Pipe Rehabilitation



Adam Brown, PE  
September 9, 2025



1

## Agenda

- About BKF
- Why Rehabilitation
- Project Scoping
- AWWA Structural Lining Classifications
- Rehabilitation Methods

Ask questions as we go!

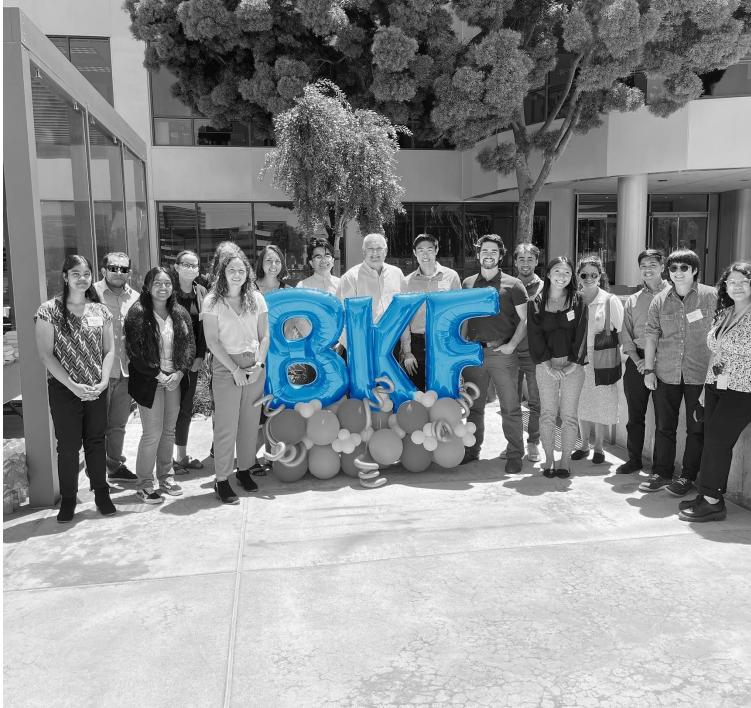


2

# About us

**480+**  
Employees

Founded  
**1915**



**18**  
West Coast Offices

**160+**  
Professional  
Engineers & Surveyors

3

# Services

Civil Engineering  
Surveying  
Planning  
Transportation  
Water Resources  
Sustainability  
Utility Locating



Fresno  
Modesto  
Newport Beach  
Oakland

Santa Rosa  
Sacramento  
San Francisco  
Walnut Creek

San Jose  
San Rafael  
Redwood City  
Riverside  
Roseville

Salinas  
San Diego  
San Luis Obispo  
Pleasanton  
Portland, OR

4

# Business Sectors



Transportation



Water Resources



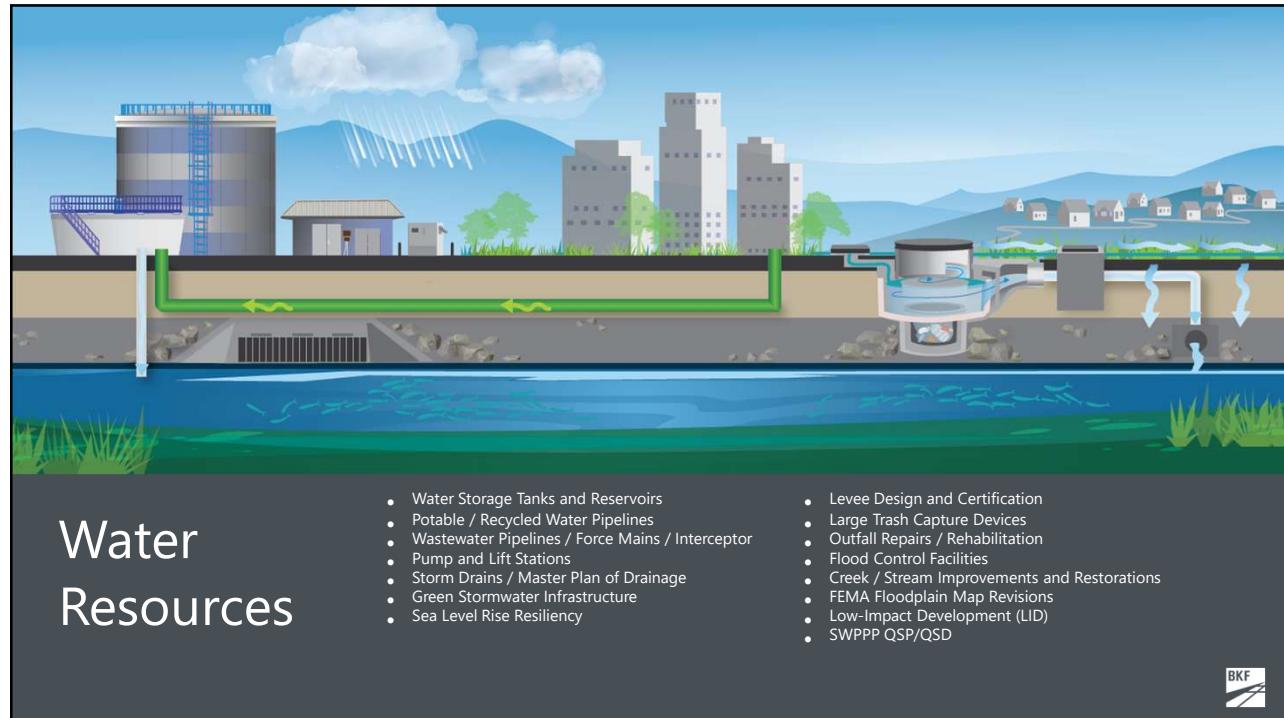
Land Development



Land Surveying



5



6

## Why Rehabilitation



7

## Limiting Disturbance



Stevens Creek Blvd (sjwater.com)



Stevens Creek Blvd (sjwater.com)

Heavy traffic, working hours shifted to 6 AM to 3:30 PM, retail store presence



8

## Lack of Access



Elm Park WM, Monte Sereno



Elm Park WM, Monte Sereno

20" pipeline, private property, established vegetation



9

## Utility Congestion



Redwood City Sewer Capacity Improvements (Civil Grid)



Redwood City Sewer Capacity Improvements (Civil Grid)

Finding room for a separate 36" sewer line may be challenging...



10

## Save Time / Money

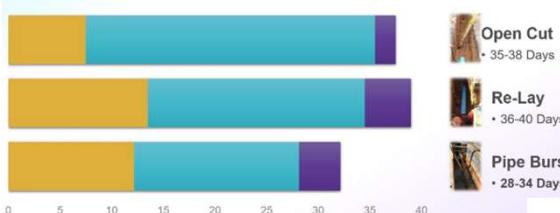
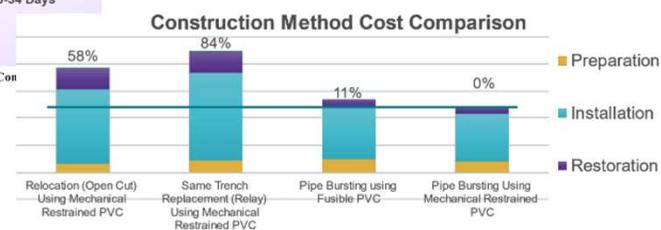


Figure 5. Operations Steps/Timelines Associated with the Lanham Station Construction – Total Con 500 LF of Construction

No-Dig Proceedings Booklet



No-Dig Proceedings Booklet



11

## Project Scoping

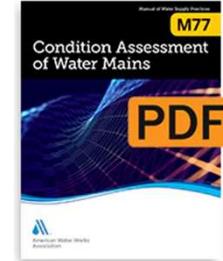


12

# Project Scoping

## Key Considerations

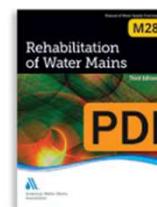
- Condition assessment challenging; no access
  - See AWWA M77 for info
- “Trenchless” does not mean “no excavation”
- Materials / products / equipment are often not cheap
- Rehab programs can help realize economies of scale
- Mixing / matching methods can yield best value
- Use bid alternatives for comparable methods
- Standardize a method or evaluate case-by-case?



13

# Project Scoping

- Project-Specific Evaluation Criteria
  - Structural deficiencies
  - Design life
  - Site constraints and obstructions
  - System pressures
  - Hydraulic capacity
    - According to AWWA M28



<https://www.amesburyma.gov/ImageRepository/Document?documentId=468>

Table 1-1 Hazen-Williams roughness coefficient

Condition	C
New pipe	130-140
Fair to normal (interior clean)	100
Significant reduction in pipe capacity	70
Severe problem—interior cross section greatly reduced	30-50

$$V = A C R^{0.63} S^{0.54}$$

← Hazen-Williams Equation



14

# Project Scoping

## Pipe Condition

- Is pipeline suffering from internal or external corrosion?
- Can we rely on host pipe?
- Does host pipe have holes? How big?

## Hydraulics

- Can pipe diameter be reduced?
- Does diameter need to be increased?
- What system pressures are required?

## Disturbance

- How long can pipeline be shutdown?
- How many services are on the line?
- How disruptive will excavation be?

## Loading

- What dead/live loads need to be supported?

## Material

- Is AC pipe involved?
- Is pipe burstable?

## Bypass

- Can services/hydrants operate during installation?



15

## Structural Lining Classifications



16

## Structural Lining Classifications

- **Class I Lining**

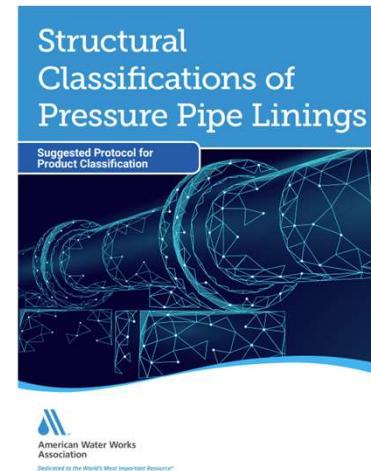
- Nonstructural
- Protect inner surface of host pipe from further corrosion/tuberculation
- Host pipe still provides all internal/external load resistance

- **Class II and III**

- Semi-structural systems
- Can sustain internal pressure loads, but relies on host pipe for external loads
- Can bridge holes/gaps in host pipe
- **Class II:** depend on adhesion to host pipe to prevent collapse
- **Class III:** sufficient ring stiffness to be self-supporting

- **Class IV**

- Structurally independent equivalent to replacement pipe



17

## Structural Lining Classifications

Method	Class I	Class II/III	Class IV
SIPP	X	X	
FFRP		X	
CIPP		X	X
<b>Sliplining*</b>			X
<b>Pipe Bursting / CTPS*</b>			X
MICP			X
CFRP			X

\*method results in installation of new pipe, not a liner



18

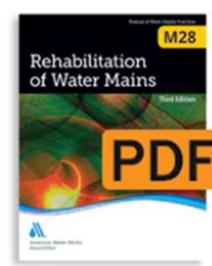
## Rehabilitation Methods



19

## Rehabilitation Methods

- Spray-In-Place Pipe (SIPP) Linings
- **Flexible Fabric Reinforced Pipe (FFRP)**
- **Cured-In-Place Pipe (CIPP)**
- **Sliplining**
- **Pipe Bursting**
- Manufactured In Place Composite Pipe (MICP)
- Close Tolerance Pipe Slurification (CTPS)
- Carbon Fiber Reinforced Polymer (CFRP)



**Note: BKF does not endorse any products, contractors, or manufacturers**



20

## Spray-in-Place Pipe (SIPP) Linings



21

AWWA M28, Chap. 5 and 6 / ANSI/AWWA C602 and C620

### SIPP

- Typically Class I, but can be Class II and III
  - Epoxy/mortar – minimal strength enhancement
  - Polyurea – multiple coats can enhance strength
- Coating that protects the host pipe
- Applied mechanically (spincaster)
- Length controlled by equipment
  - AWWA suggests around 600 to 700 feet
- Returned to service
  - 4 to 7 days for mortar
  - Same day for rapid set polymers
- Negligible hydraulic capacity reduction



Figure 6-1, AWWA M-28

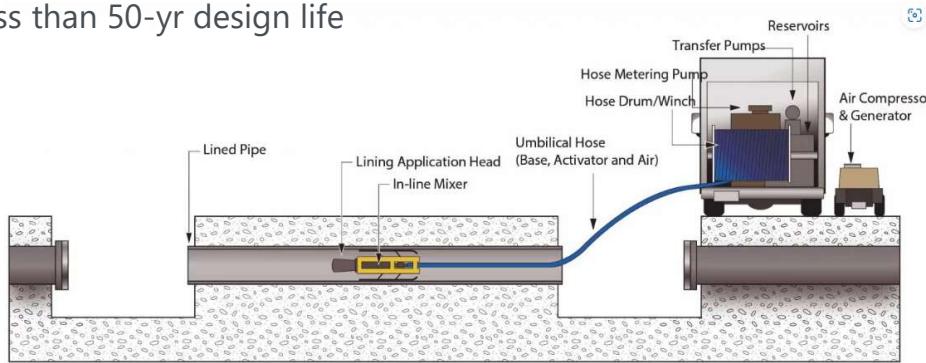


22

AWWA M28, Chap. 5 and 6 / ANSI/AWWA C602 and C620

## SIPP

- Need to clean/inspect pipe prior to application
- Claim to navigate 45-deg bends, but recommended to verify with mfr
- Less than 50-yr design life

Source: <https://www.sippamericas.com/sipp-lining-equipment/>

23

AWWA M28, Chap. 5 and 6 / ANSI/AWWA C602 and C620

## SIPP

**SIPP Americas (<https://www.sippamericas.com/>)**

- 2-part, non-water-sensitive polyurea (4" to 42")
- 1mm to 3.5mm in a coat; 14mm max thickness
- Can CCTV 15min after coating; 60 min return to service  
–8hr re-coat window
- 360 psi short-term burst pressure for 6" pipes  
–Decreases as diameter increases
- Can be designed for Class I thru Class III (and "Class III+")
- Can line up to 1,350 feet in a day; 2,600 feet in two days with 2 pits
- Trying to compete with CIPP for pipes in decent condition



24

## Flexible Fabric Reinforced Pipe (FFRP)

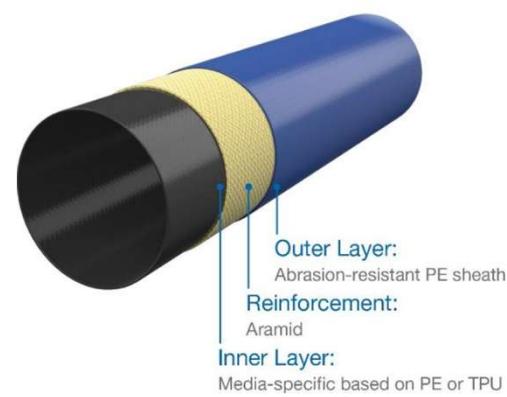


25

Not In AWWA M28, ASTM F3708 for Primus

### FFRP (Primus Line, Bullet Liner)

- 2 primary manufacturers
  - Bullet Liner (Asia)
  - Primus Line (Europe)
- Doesn't require curing
  - PE inner/outer layer, fabric for middle layer
- 50-yr design life
- Can't be tapped
- Excavation limited to pit at each end
  - Can be as small as approx 5'x8'
- Pulled through, inflated with air, single-day install (depending on the length)



Source: Primus Line Literature

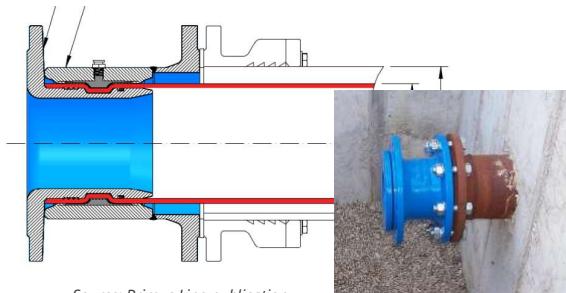


26

Not In AWWA M28, ASTM F3708 for Primus

## FFRP (Primus Line, Bullet Liner)

- 35-40% cheaper than CIPP
  - According to Primus rep
- All installers have to be certified to work on the liner or fittings



27

Not In AWWA M28, ASTM F3708 for Primus

## FFRP (Primus Line, Bullet Liner)

Method	Bullet Liner	Primus Line
Diameters	4" to 48"	6" to 18"
Operating Pressures**	Up to 232 psi*	Up to 1,189 psi
Annular Space / Type of Fit	None / Close	Varies / Loose
Pressure De-Rating at Bends	No	Yes

\*manufacturer says they can make custom liners to withstand higher pressures

\*\*depends on liner size/type (not every liner size can withstand max pressures shown here)

### Other Considerations:

- Kevlar vs no Kevlar and how many layers
- 3<sup>rd</sup> party testing available or not
- NSF 61 certification of liner/fittings for the materials used
- ASTM F3708 for Primus / loose-fit



28

## Cured-In-Place Pipe (CIPP)



29

AWWA M28, Chap 7 / ASTM F1216

## CIPP

- Glass-reinforced felt lining inverted into host pipe and cured
- Class IV – fully structural solution
  - Class III using “partially deteriorated condition”
- Diameters: 4” to 108”
- Negligible capacity reduction
  - Rule of thumb: (dia in inches) / 2 = mm
- Max operating pressure = 250 psi
- Pit sizes similar to FFRP



<https://trenchlesstechnology.com/aegion-corp-continues-focus-trenchless-technology/>



30

## CIPP

- 50-yr design life
- Can be tapped
- 2 to 6 hr cure time (average)
  - Hot water cure
- Valves and tees/crosses need to be removed
  - Usually place pits at these locations
- Can restore services robotically
- Historically, service taps have been weak points, but technology is always evolving



<https://trenchlesstechnology.com/aegion-corp-continues-focus-trenchless-technology/>



31

## Sliplining



32

## Sliplining

- Pulling smaller pipe into host pipe
  - Grouting annular space
- Typically install PVC or HDPE with limited disruption
- Requires capacity reduction
- Can't pull through bends, valves, fittings
- Pits are usually larger for fused pipe to accommodate pipe curvature to reach depth
  - Restrained joint PVC can reduce pit sizes and pipe staging area
- Requires excavation to restore services



33

## Sliplining

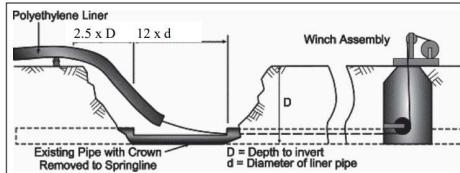


Figure 6 Typical Sliplining Access Pit for Prefused Lengths of Polyethylene Liner



[https://www.westlakepipe.com/sites/default/files/MU-BR-002-US-EN-0522.1\\_Segmented-PVC-vs-HDPE.pdf](https://www.westlakepipe.com/sites/default/files/MU-BR-002-US-EN-0522.1_Segmented-PVC-vs-HDPE.pdf)



<https://www.wiawwa.org/general/custom.asp?page=vendorundergoodsolutions>



34

# Pipe Bursting



35

## Pipe Bursting

- Breaks old pipe; new pipe installed in same location
  - End result is new pipe
- Only method that can upsize the pipe
  - Up to about 2 pipe sizes
- Can't pull through acute bends, valves
- Pits are usually larger for fused pipe to accommodate pipe curvature to reach depth
  - Restrained joint PVC can reduce pit sizes and pipe staging area
- Requires excavation to restore services



IT Technologies



36

## Pipe Bursting

- Challenging materials
  - Steel should not be too thin
  - DIP not always predictable
  - Can't burst bar-wrapped, reinforced pipe
- Heave
  - Shallow cover may damage surface as soil compresses outward from pipe
  - Need (2 to 3) foot cover + (1 to 2) feet for every inch of upsize
- Pneumatic vs Static Bursting
  - Pneumatic hammer used on fracturable pipe
  - Static system used to split pipe (constant pull)
  - Pneumatic can only install HDPE; can damage other pipe
  - Static can install fusible or segmental pipe

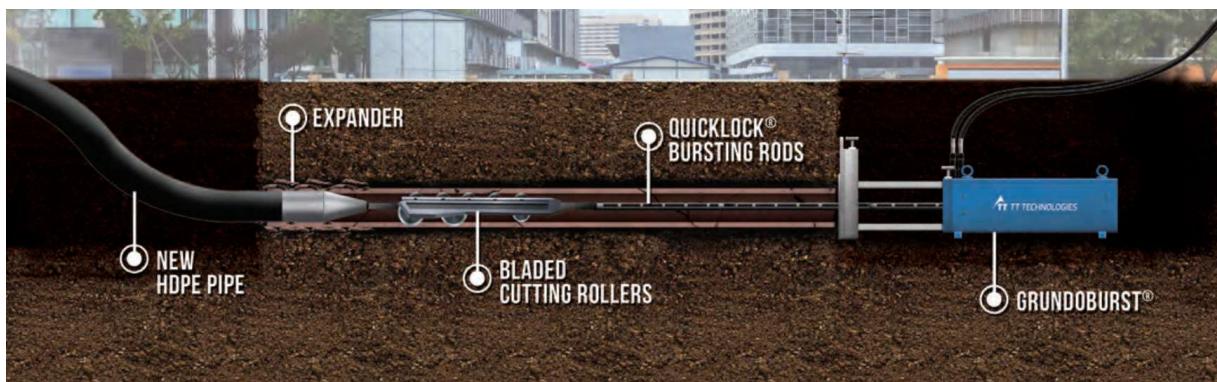


TT Technologies



37

## Pipe Bursting



TT Technologies

Case studies claim potential for 30% savings compared to open-cut, even digging up services



38

19

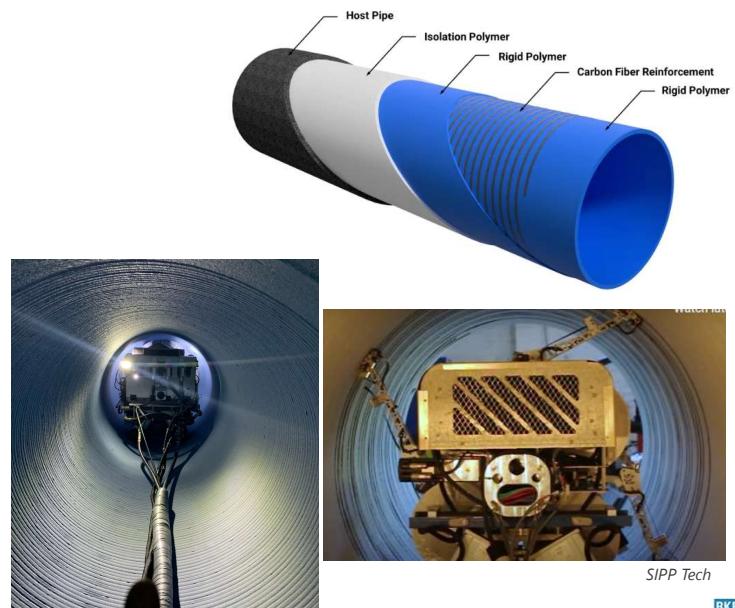
## Manufactured-In-Place Composite Pipe (MICP)



39

### MICP

- Only one known manufacturer
  - SIPP Tech
- 48" to 96"
- 250 psi and above



40

## Close Tolerance Pipe Slurification (CTPS)



41

## CTPS

- Trenchless removal and replacement of AC pipe
- Reamer grinds AC pipe into slurry that gets pumped out while pulling in new pipe
- Relatively new concept
  - EPA-approved in 2019
- Limited contractor pool
- Only being marketed by Azuria



**Federal Register / Vol. 84, No. 111 / Monday, June 10, 2019 / Notices**

strident as the NPOWRS at 40 CFR parts 141 and 142, as well as adopt all new and revised regulations to retain primacy (40 CFR 142.12(a)).

**B. How does this action affect Indian country?** (18 U.S.C. 1131) (b) (1) (B)

The State of Utah's revised PWSS program does not extend to Indian country as defined in 18 U.S.C. 1131. Indian country, as defined, includes (1) lands within the exterior boundaries of the following Indian reservations located within Utah, in part or in full: The Goshute Reservation, the Navajo Nation, the Hopi Reservation, the Navajo Reservation lands of the Paiute Indian Tribe of Utah (Cedar Breaks Paiutes, Kanab Paiutes, and Kaibab Paiutes), Band of Paiutes, Indian Peaks Band of Paiutes, Shoshone Band of Paiutes, the Skull Valley Indian Reservation, the Uintah and Ouray Reservation (subject to federal recognition), and (2) certain lands from Indian country status within the Uintah and Ouray Reservation, the San Juan Southern Ute Reservation; (2) any land held in trust by the United States for a Native tribe; and (3) any other areas which are "Indian country" within the meaning of 18 U.S.C. 1131. The State, as appropriate, will retain PWSS program responsibilities over public water systems in Indian country.

Please bring this notice to the attention of any persons known by you to have an interest in this determination.

**Dated:** May 28, 2019.  
**Gregory Sopkin,**  
 Associate General Counsel, Region 8  
 (PR Doc. 2019-12102 Filed 6-7-19; 8:45 am)  
**BILLING CODE 6560-50-P**

**ENVIRONMENTAL PROTECTION AGENCY**  
 [EPA-HQ-OAR-2017-0427; FR: 9994-29; OAR]

**RIN 2050-AT73**

**Notice of Emission Standards for Hazardous Air Pollutants for Asbestos: Notice of Final Approval for an Alternative Work Practice Standard for Asbestos Cement Pipe Replacement**

**AGENCY:** Environmental Protection Agency (EPA).

**ACTION:** Notice of final approval.

**FOR FURTHER INFORMATION CONTACT:** For questions about this final action, contact Mr. Korbin Smith, Sector Policies and Programs Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711; telephone number: (919) 541-2411; fax number: (919) 541-2411; and email address: [smith.korbin@epa.gov](mailto:smith.korbin@epa.gov).

For questions about the applicability of this final action, contact Mr. John Smith, Office of Enforcement and Compliance Protection Agency, WIC Sector Building, 1200 Pennsylvania Avenue NW, Washington, DC 20460; telephone number: (202) 564-1395; and email address: [cex.john@epa.gov](mailto:cex.john@epa.gov).

**SOURCE OF INFORMATION:**

**Acronyms and abbreviations:** We use multiple acronyms and terms in this document. While some may be descriptive, they may not be exhaustive, to ease the reading of this document and for reference purposes, the following terms and



42

# CTPS

» 2019 Alternative Work Practice Issued

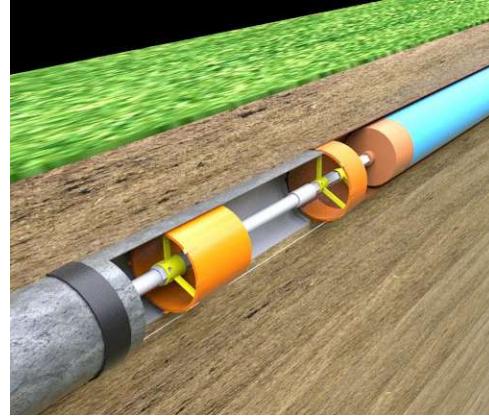
» 2022 EPA Memo

» 2023 ASTM Standard for CTPS



## CTPS TECHNICAL ENVELOPE

Diameter Range	4" - 20"
Upsizing	Yes
Host Pipe Material	Asbestos Cement (AC)
Application Types	Potable Water & Sewer Force Main
Typical Install Length	500+ LF
Installation Standard	ASTM F3632-23
Pressure Rating	Per AWWA Standards



43

## Carbon Fiber Reinforced Polymer (CFRP)



44

## CFRP

- For 30-inch diameter and above
  - Requires manned entry
- Polymer applied and cured to host pipe
- Applied like wall paper in sheets
- Mainly used in large diameter concrete pipelines
- Reinforces structural stability of host pipe
  - Class IV fully-structural rehab
- Very expensive



45

**Putting It All Together...**



46

## Example #1

Criteria:

- 14" and 16" steel water transmission main (no services)
- Existing headloss/pumping issues
- Installed in 1960s (poor as-builts)
- Numerous past failures
- Pressures between 150 and 300 psi
- Mostly 3 ft of cover
- Along a bike path, numerous bends/fittings
- Wanting 50-yr design life



47

## Example #1

Method	Applicable?	Reason	Action Items
SIPP			
FFRP			
CIPP			
Sliplining			
Pipe Bursting			
CTPS			
MICP			
CFRP			



48

## Example #2

Criteria:

- 6" cast iron water distribution main (w/ services)
- Min agency standard is 8" for fire flow
- Good as-builts (can locate all bends/valves/etc.)
- Replaced for age; not many failures
- Pressure = approx. 60 psi
- Mostly 3 ft of cover
- Residential neighborhood
- Wanting 50-yr design life



49

## Example #2

Method	Applicable?	Reason	Action Items
SIPP			
FFRP			
CIPP			
Sliplining			
Pipe Bursting			
CTPS			
MICP			
CFRP			



50

## Example #3

Criteria:

- 48" steel water transmission main (no services)
- No capacity issues
- Aged, critical pipeline; high consequence of failure
- 50% of pipe wall left
- Pressures above 250 psi
- 6 ft of cover; little to no bends
- Beneath a high-volume roadway
- Wanting 50-yr design life



51

## Example #3

Method	Applicable?	Reason	Action Items
SIPP			
FFRP			
CIPP			
Sliplining			
Pipe Bursting			
CTPS			
MICP			
CFRP			



52

